Coronavirus (COVID-19)

Modeling the Outbreak

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Biomath coffee

February 25, 2020.

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Exponential growth of cases

Coronavirus disease 2019 (COVID-19)
Situation Report – 34 & 26 & 12

World Health Organization

SITUATION IN NUMBERS
total and new cases in last 24 hours

Globally
78 811 confirmed (1017 new)

China
77 042 confirmed (650 new)
2445 deaths (97 new)

Outside of China
1769 confirmed (367 new)
28 countries
17 deaths (6 new)

WHO RISK ASSESSMENT

China	Very High
Regional Level	High
Global Level	High

23 Feb 20

SITUATION IN NUMBERS
total and new cases in last 24 hours

Globally
50 580 laboratory-confirmed (1527 new)

China
50 054 laboratory-confirmed (1506 new)
1524 deaths (121 new)†

Outside of China
526 laboratory-confirmed (21 new)
25 countries (1 new)
2 deaths

WHO RISK ASSESSMENT

China	Very High
Regional Level	High
Global Level	High

15 Feb 20

SITUATION IN NUMBERS
total and new cases in last 24 hours

Globally
11953 confirmed (2128 new)

China
11821 confirmed (2102 new)
1795 severe (268 new)
259 deaths (46 new)

Outside of China
132 confirmed (26 new)
23 countries (4 new)

WHO RISK ASSESSMENT

China	Very High
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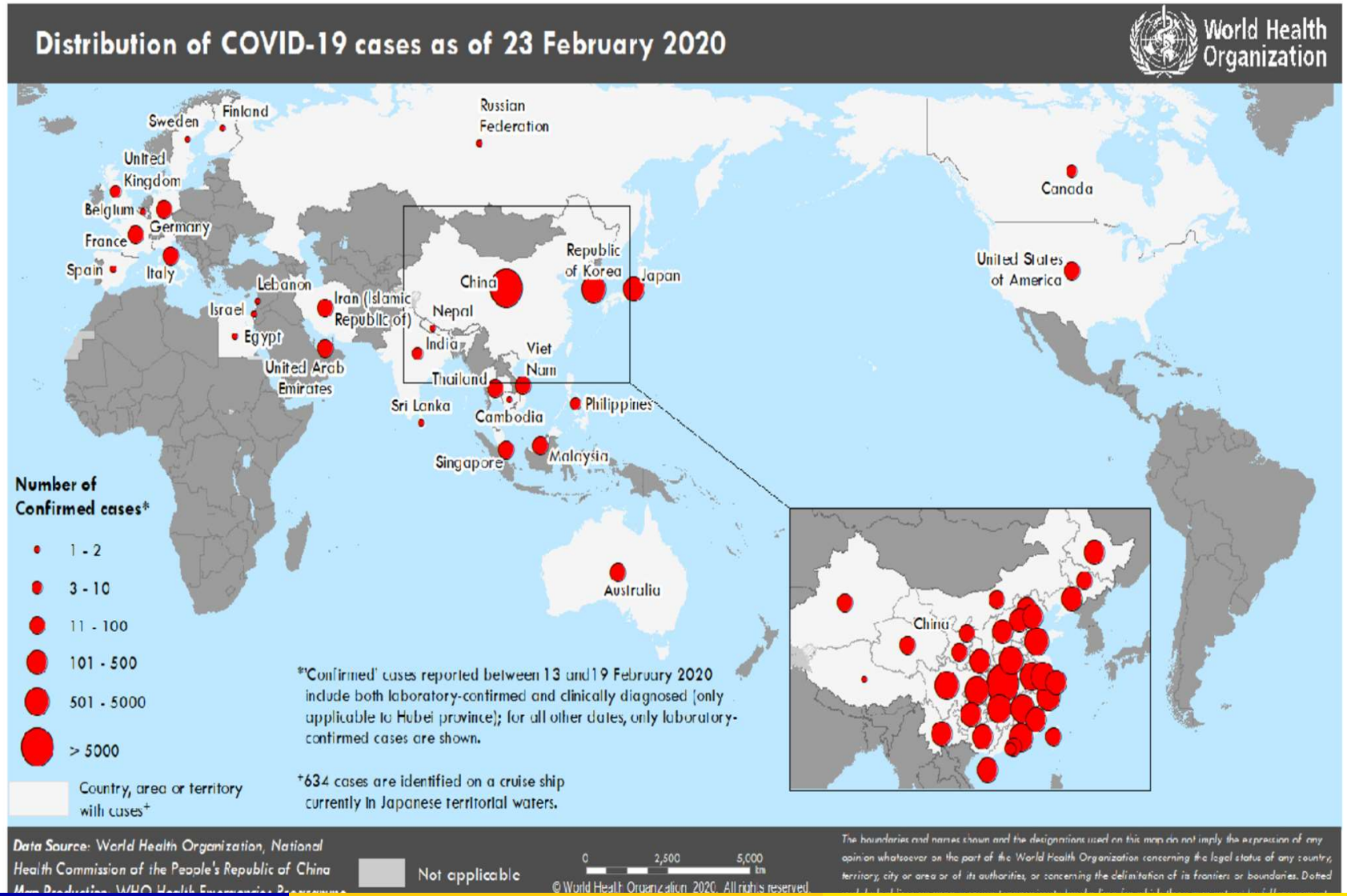
01 Feb 20

Pandemic situation

Figure 1. Countries, territories or areas with reported confirmed cases of COVID-19, 23 February 2020



- https://youtu.be/mOV1aBVYKGA
- present data don't inform the direction of transmission;
- Original source is **unknown**;
- There is no vaccine or specific antiviral treatment.

Widen consequences include:

- potential economic instability;

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- xenophobia and racism against Chinese and Asians.

Current control measures

The main control measures applied include:

- Quarantine of;
  - Cruise ships in Japan water and nearby China;
  - Carfew of over 170million people in China.
- Isolation of individual with clinical symptoms;
- Body temp check in major airports and trains around the world;
- warning against travel to China.

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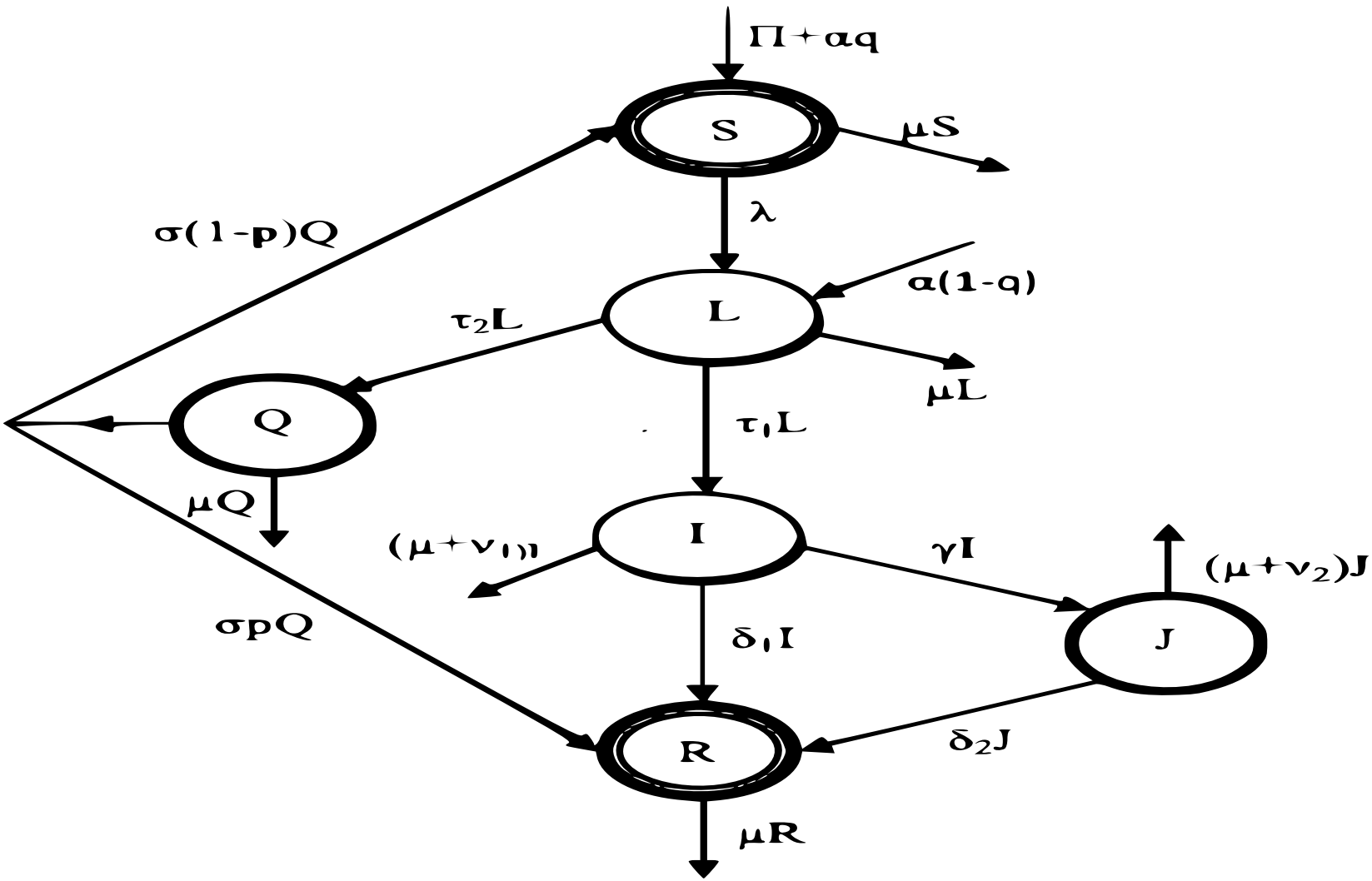
Flow diagram of the Model



Model Equations

$$
\begin{aligned}
\frac{dS}{dt} &= \Pi + \alpha q + \sigma(1-p)Q - (\lambda + \mu)S, \\
\frac{dE}{dt} &= \alpha(1-q) + \lambda S - (\tau_1 + \tau_2 + \mu)E, \\
\frac{dI}{dt} &= \tau_1 E - (\gamma + \nu_1 + \delta_1 + \mu)I, \\
\frac{dQ}{dt} &= \tau_2 E - (\sigma + \mu)Q, \\
\frac{dJ}{dt} &= \gamma I - (\nu_2 + \delta_2 + \mu)J, \\
\frac{dR}{dt} &= \delta_1 I + \delta_2 J + \sigma p Q - \mu R,
\end{aligned}
\tag{1}
$$

with

$$
\lambda = \frac{\beta(I + \eta_1 E + \eta_2 Q + \eta_3 J)}{N}
$$

Existence of Equilibria

Lemma

The model (1), *has no disease free equilibrium* ($q \neq 1$ *in exposed class).*

we define an invasion threshold $\mathcal{R} = \frac{\beta(\Pi+\alpha)[\tau_1 K_3(K_4+\eta_3\gamma)+K_2K_4(\eta_1K_3+\eta_2\tau_2)]}{K_1K_2K_3K_4(\Pi+\alpha q)}$.

Theorem

Model (1) *has:*

(i) *a unique endemic equilibrium for all values of* $\mathcal{R}$ *if* $q \in [0,1)$ *and* $\alpha > 0$,

(ii) *a unique EE if* $\mathcal{R} > 1$ *and either* $q = 1$ *or* $\alpha = 0$,

(iii) *no EE if* $\mathcal{R} < 1$ *and either* $q = 1$ *or* $\alpha = 0$.

Quarantine and Isolation Strategies

- Investigated via threshold analysis approach on $\mathcal{R}_c|_{(\tau_2,\gamma)}$;
- for Quarantine:

$$\frac{d\mathcal{R}_c}{d\tau_2} = \frac{\beta\eta_2}{K_1K_2} - \frac{\beta[K_2K_4(\eta_1K_3+\eta_2\tau_2)+\tau_1K_3(K_4+\eta_3\gamma)]}{K_1^2K_2K_3K_4}, \quad (2)$$

from (2)

$$\eta_2^* = \frac{\eta_1K_2K_3K_4+\tau_1K_3(K_4+\eta_3\gamma)}{K_2K_4(\tau_1+\mu)}.$$

Therefore,

$$\frac{d\mathcal{R}_c}{d\tau_2} \lessgtr 0 \text{ iff } \eta_2 \lessgtr \eta_2^*.$$

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- Similarly for Isolation:

$$\frac{d\mathcal{R}_c}{d\gamma} \lessgtr 0 \text{ iff } \eta_3 \lessgtr \eta_3^*.$$

Proposition

The use of quarantine of the exposed individuals will have positive (negative) impact in a community if $\eta_2 \lessgtr \eta_2^*$.

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Similarly,

Proposition

The use of isolation of infectious individuals will have positive (negative) impact in a community if $\eta_3 \lessgtr \eta_3^*$.

Research Objectives

- To assess the transmission dynamics of CoVID-19 for future predictions.
- To determine the impact of **Quarantining** and **Isolation** strategies in controlling the disease.
- More questions to come**?????????**

Thank you for your attention